160 Meters – Mastering the Challenge

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Who Is K9LA?

- Licensed in October 1961 as WN9AVT
- Selected K9LA in 1977
- Enjoy DXing, contesting, propagation, antennas and vintage equipment
- 160m DXCC in Sep 2002
  - 180 countries worked mostly using inverted-L for TX and RX
  - Recently installed Shared Apex Loop array for RX
- 160m DXCC card checker

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Topics

- Common issues
  - History of 160m
  - Current band plan
  - Frequency allocations
- Issues for newcomers
  - When is the band good?
  - Simple TX antennas
  - Noise
  - Amplifiers
  - Simple RX antennas
  - Propagation tips
- Issues for experienced ops
  - Advanced TX antennas
  - Advanced RX antennas
  - Advanced propagation tips
  - Required elevation angles
- References
- Summary
- Cycle 24 Update

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Common Issues

A History of 160m

- 160m has been around a very long time
- 1926 ARRL Handbook
  - Allocation from 150 to 200 meters
    - 2 MHz down to 1.5 MHz
- Due to AM broadcast and other services (police band, for example), 160m eventually narrowed up to 1.8-2.0 MHz
- LORAN dictated frequency and power restrictions in the early days
  - In my General days in early 1962 in NW Indiana, I could operate from 1.800-1.825 MHz with 200 Watts
- For many, many years it has been called “The Gentleman’s Band”

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Current Band Plan

1.800-2.000	CW
1.800-1.810	Digital modes
1.810	CW QRP
1.843-2.000	SSB, SSTV
1.910	SSB QRP
1.995-2.000	Experimental
1.999-2.000	Beacons

- The FCC does not regulate 160m with respect to band segmentation by mode
- Legally any mode can operate anywhere
- ARRL band plan is the table on the left
- Lots of room above 1.9 MHz for local QSOs

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Frequency Allocations

- Not all countries have the same frequency allocations on 160m as we do
- So if you're chasing DX, knowing the frequency allocation of the various DXCC entities is important
- http://www.qsl.net/n1eu/topband/160FreqAlloc.xls

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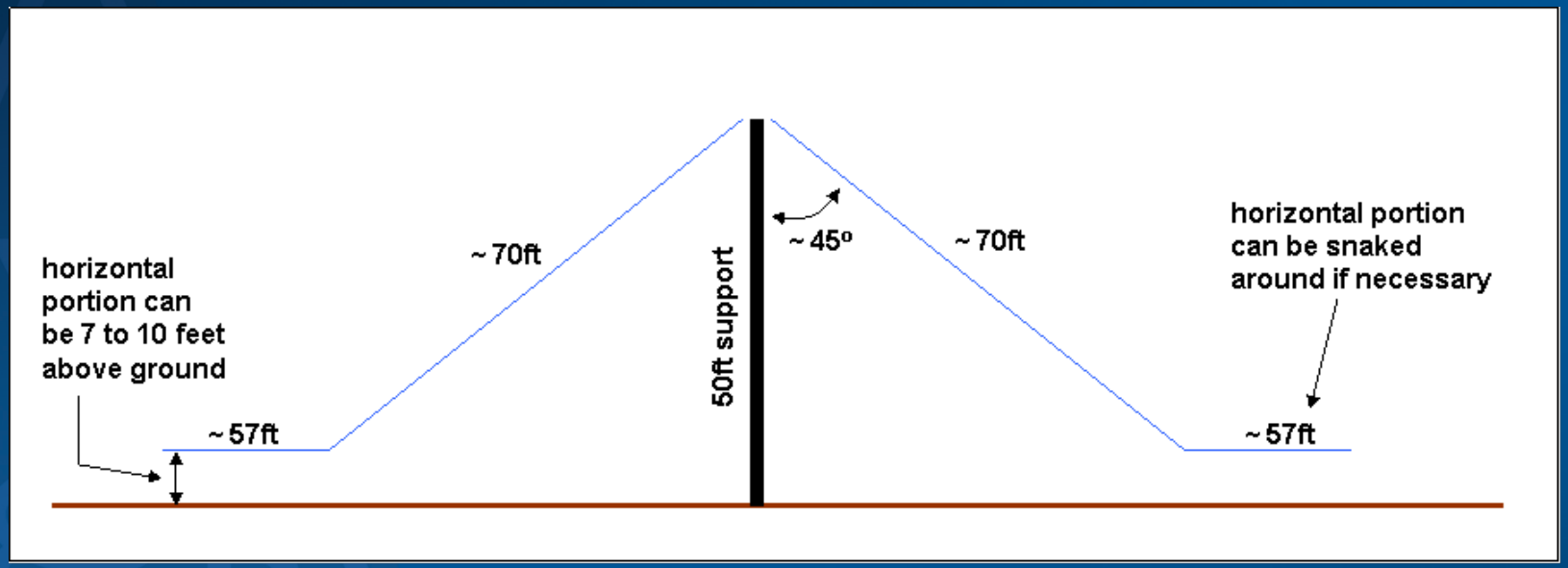
Issues for Newcomers

When Is the Band Good?

- For local QSOs, 160m is good any time
  - Day, night, summer, winter
  - Great NVIS band
  - With 1000 Watts and quarter-wave verticals, you should be able to communicate on CW out to 500 miles at high noon in winter on 160m
- For DX QSOs, there are times, seasons and phases of a sunspot cycle when 160m is best
  - Due to ionospheric absorption and geomagnetic field considerations, the dark ionosphere in winter at solar minimum is best

Simple TX Antenna: Inverted-V



- Each side about 127 ft
- Can snake the ends around to fit your QTH
- Good antenna for domestic contests and common DX
- Support could be tower, tree or guyed mast

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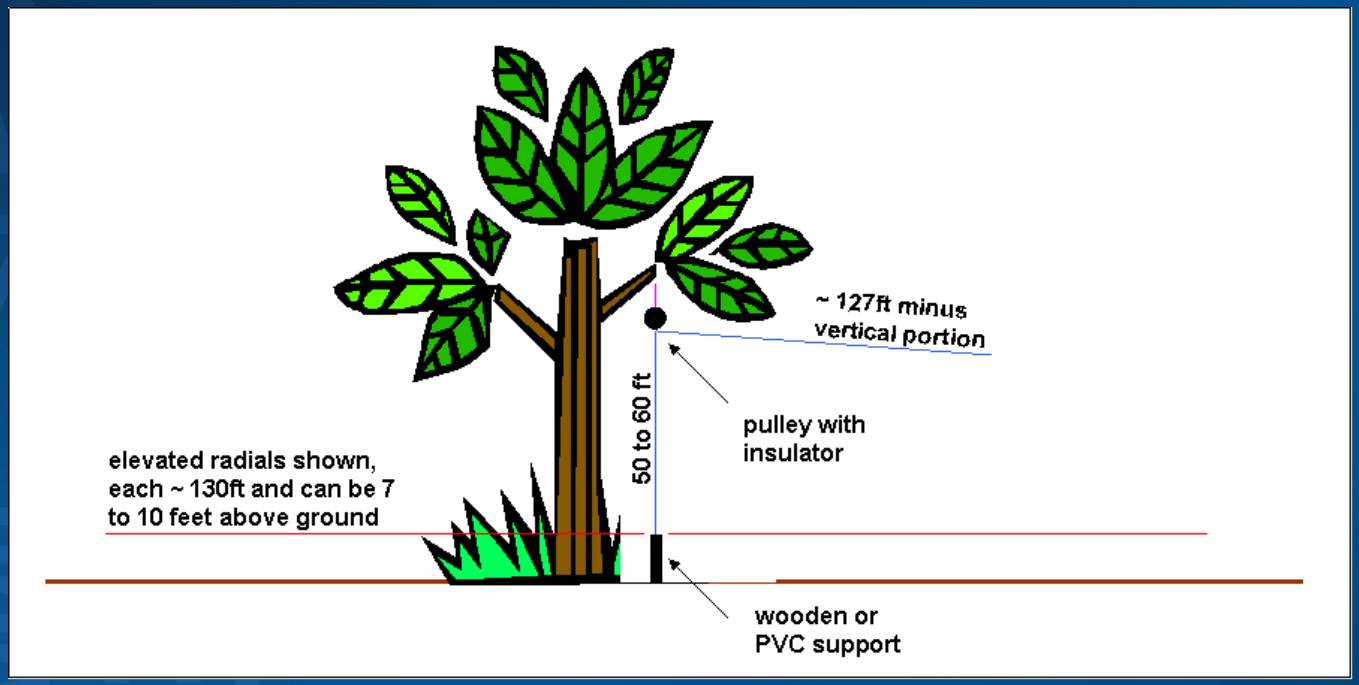
Simple TX Antenna: Inverted-L



- Radiator about 127 ft
- A couple elevated radials about 130 ft at 7 ft high
- Good antenna for DXing
- Support could be tower, tree or guyed mast

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Simple TX Antenna: Vertical

- Make it as high as possible – preferably a quarter-wave
- If it has to be physically shorter, load it for resonance
  - Top loading with top hat the best
  - Center loading with coil next best
  - Base loading with coil easiest but last
- If loading with coil, use large diameter B&W inductor stock
  - http://bwantennas.com/coils/aduxlex.htm
  - For example, 2.5 inch diameter with 8 turns per inch
- Ground is very important
  - Lots of ground radials or several elevated radials

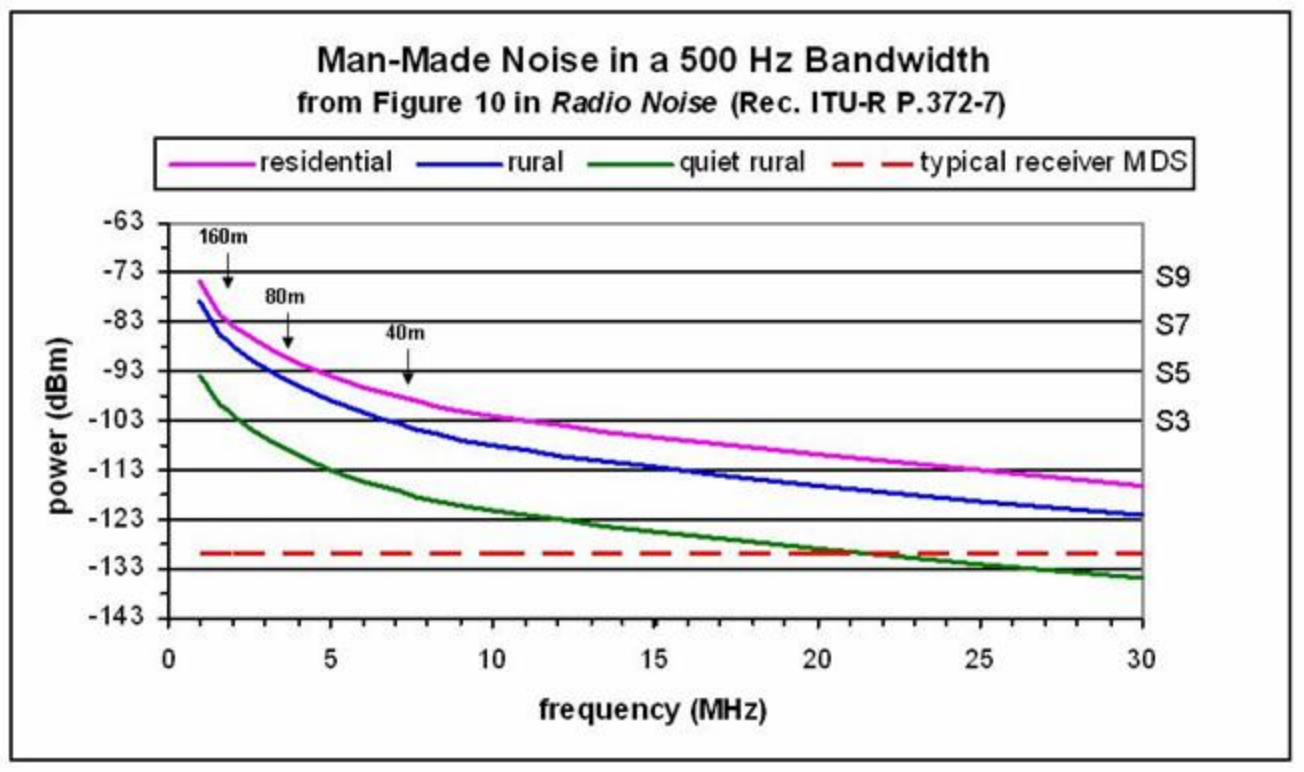
Noise

- Why is noise important?
  - Because it limits your sensitivity (hear-ability)
- Two types of noise to contend with on 160m
- Atmospheric noise
  - Due to propagation of electromagnetic energy from lightning discharges in and near thunderstorms
  - Directional in nature because it propagates into your QTH – just like real signals
  - Not much we can do about it
  - Mitigation is low-noise RX antenna system

Noise – continued

- Man-made noise
  - From machinery, appliances, lights, etc
  - Try to eliminate as much as possible
    - Check your QTH for noise sources
    - Work with power company after identifying suspect pole
    - Work with neighbors
  - My ‘most interesting’ sources
    - Defective doorbell transformer about a quarter mile away
    - Neighbor’s electric blanket for cat

Man-Made Noise



- Data used small vertical monopole and is from the 1970s
- Note difference between receiver sensitivity and noise
  - Almost 30 dB on 160m for quiet rural environment
  - Even worse in noisier environments
- I am in a quiet rural environment

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Amplifiers

- An amp is not necessary, but it sure helps!
- A small amp could make a significant difference
  - For example, AL-811 is 500W CW/600W PEP
  - That's more than an S-unit improvement over a barefoot transceiver
- If your transmit signal is at the noise level of your target location, 6 dB more signal would make it a solid QSO

Simple RX Antennas

- More than likely you'll use your TX antenna when you initially get on 160m
- If you have a persistent specific man-made noise problem, get it fixed!
- Might want to try a small loop
  - Can have deep nulls perpendicular to the plane of the loop
- Might want to try a long piece of wire on the ground
  - Could offer an improvement in SNR (signal-to-noise ratio)

Propagation Tips

- 160m RF needs to be in the dark ionosphere due to ionospheric absorption in the lower ionosphere
  - Absorption is the driving force on 160m
- Know when and how long your path to the DX station is in darkness
- There's always enough ionization to support 1.8 MHz – the MUF (maximum useable frequency) isn't an issue
- Signal enhancements on paths that are generally perpendicular to the terminator can occur around sunrise (especially on the eastern end of the path) and around sunset
- The dark ionosphere in winter at solar minimum appears to be best for 160m DXing

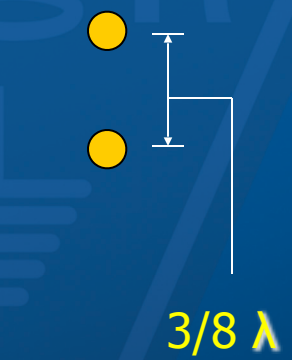
Issues for Experienced Ops

Advanced TX Antennas

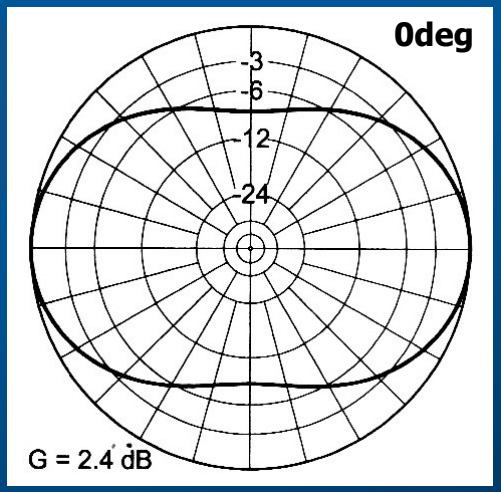
- To be louder at a distant location, you either need to add an amplifier (or a bigger one if you already have one) or upgrade to an antenna with gain
- When your signal at your target is at his noise level, 2-3 dB more signal can make all the difference
- I guess the other possibility is to install a remote station near your target!
  - Just kidding!

Advanced TX Antenna – Phased Verticals

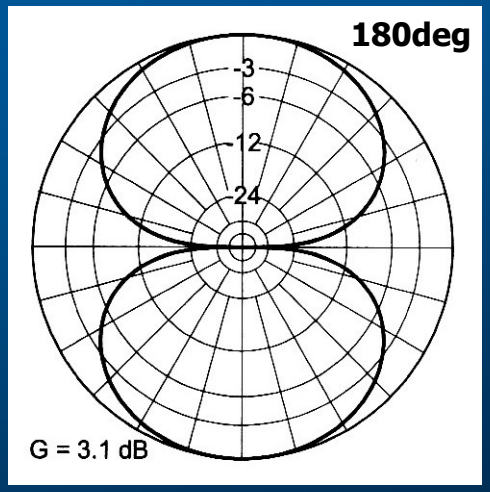
- Two phased verticals are a simple step up from an inverted-vee, an inverted-L or a single vertical
- 3/8 λ spacing offers decent broadside and end-fire patterns with gain



in-phase



out-of-phase



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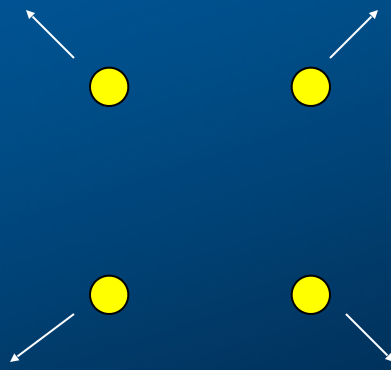
Advanced TX Antenna – 4-Square

- Next step up from two phased verticals is likely a 4-Square array
- A 4-Square is four verticals in a square configuration with ¼ λ spacing and proper phasing
- Fires in four directions
  - NE, SE, SW, NW



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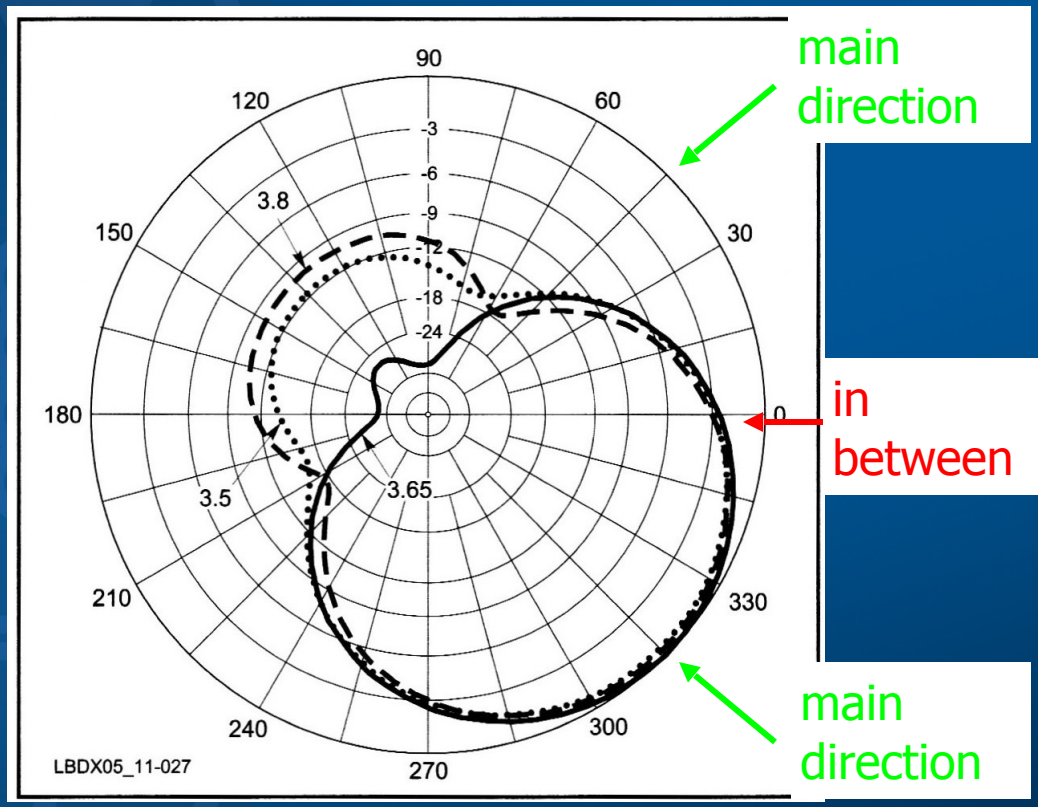
Advanced TX Antenna – 4-Square

- The 4-Square is about 3 dB down in between each of the four directions



- Is -3dB acceptable?
- That's a question you have to answer
- Can you even do anything about it?
- Yes, you can

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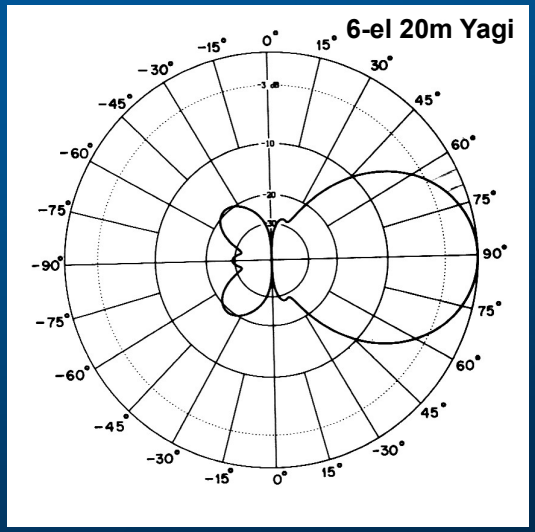
Advanced TX Antenna – More Directions

- To achieve more constant gain around the compass, best to go to more elements
- Five-Square array can fire in eight directions
- Circle arrays – can fire in eight directions
  - Six-circle array
  - Eight-circle array
  - Nine-circle array
- Generally need more real estate
- Details for antennas described herein and for many others are in ON4UN's Low-Band DXing book – including how to properly phase the elements

Advanced RX Antennas

- Basic assumption behind a low-noise receive antenna is that noise (whether it be atmospheric or man-made) arrives from around the compass (both azimuth and elevation)
- To improve SNR, desire a narrow pattern beaming in your desired direction with little response elsewhere
- In other words, you want an antenna with good directivity – like a 6-element Yagi !



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DMF and RDF

- Just like improving your transmit antenna system in successive steps, you can improve your receive antenna system in steps
- To judge the improvement, two parameters have been developed
  - DMF (directivity merit figure) – ratio in dB of forward lobe gain to average gain over the back 180^{o} of antenna
  - RDF (receiving directivity factor) – ratio in dB of forward lobe gain to average gain in all directions
- I will use RDF for the remainder of this presentation

RDF Comparisons

Antenna	Gain	RDF
Inverted vee 120 ft.	-1.08dBi	0.6
10 Foot Dia. tuned loop	2.2dBi	4.0
90 ft. top loaded TX vertical	1.4 dBi	4.9
Beverage 300 Ft.	-14.5dBi	6.5
K9AY loop	-25.6 dBi	7.2
Flag	-29.7dBi	7.4
Beverage 500 Ft.	-10.6dBi	9
2 element hiz 50ft space	amplified	9.0
4 square of K9AY loops	-22.2 dBi	9.1
Shared Apex Loop 20ft base	amplified	9.5
4 square Tx antenna	6.8dBi	10.7
TJR 4 element of 8 200ft circle Hi Z	amplified	10.8
Beverage 910 Ft.	-5.3dBi	11.9
Waller Flag	-54dBi	12.2
Beverage 1000 Ft.	-6.4dBi	12.3
330 ft circle 4 active of 8 Hi Z	amplified	12.3
Broadside-endfire Hiz vert array 70x320	amplified	12.9
TJR 8 element 200 ft circle Hi Z	amplified	13.45
Beverage pair 1000 ft. 400 ft. space	-2.9dBi	14.6

- From K7TJR's web site
- I added the Shared Apex Loop array

- Assumption is that noise arrives from all around the compass (az and el)
- Note that the inv-vee has minimal RDF – it is pretty much omni-directional at a low height - it receives signals and noise all around the compass
- The 90 ft top loaded vertical has an RDF of 4.9 dB because it has a null in its pattern straight up and at high elevation angles
- My Shared Apex Loop array has an RDF of 9.5 dB
  - **SNR improvement should be 8.9 dB over an inv-vee and 4.6 dB over a vertical**

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Advanced RX Antennas

- Use the table on the previous page to incrementally improve your receiving ability
- I worked over 165 countries while receiving with my inverted-L in a quiet rural environment
- My recently-installed Shared Apex Loop array has opened up another layer in hear-ability
  - I've worked new ones that I couldn't hear on the inverted-L
- In the future I might be able to add a long reversible Beverage in the NE-SW direction
  - Should open up another layer of hear-ability

Advanced Propagation Tips

- Watch for extremely long distance gray line paths
  - Due to ionospheric absorption issues along the terminator, I believe the electromagnetic wave does NOT follow the terminator, but gets away from the terminator and cuts across the dark ionosphere to make it look like it's following the terminator – requires a skew point
  - These paths manifest themselves as "southwest at your sunrise" and "southeast at your sunset".
- Solar minimum during the winter months appears to be best for 160-Meter propagation
  - But lots of DX can be worked at solar max and even during the summer – if you and other stations are active!
- A quiet geomagnetic field is best
  - But watch for skewed paths at high latitudes with elevated K indices
  - Additionally, watch for signal enhancements at high latitudes when the K index spikes up.

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Required Elevation Angles

- N6BV has generated statistical patterns of elevation angles from IONCAP for HF (80m-10m)
- Does not include 160m as our propagation predictions do not cover 1.8 MHz
  - Electrons spiraling around magnetic field lines interact with 160m RF – propagation get complicated
- Can determine elevations angles on 160m using Proplab Pro
  - Ray tracing program that includes the Earth's magnetic field and collisions between electrons and neutral atmospheric constituents

Required Elevation Angles

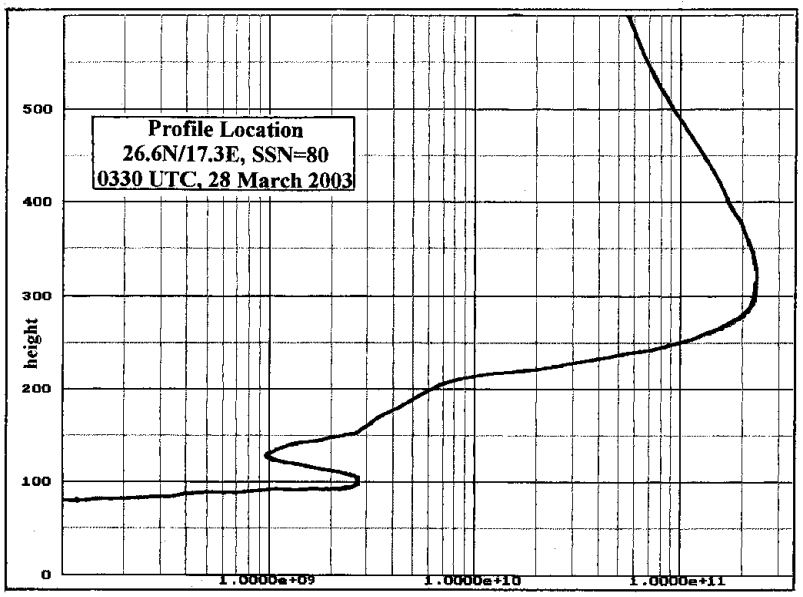
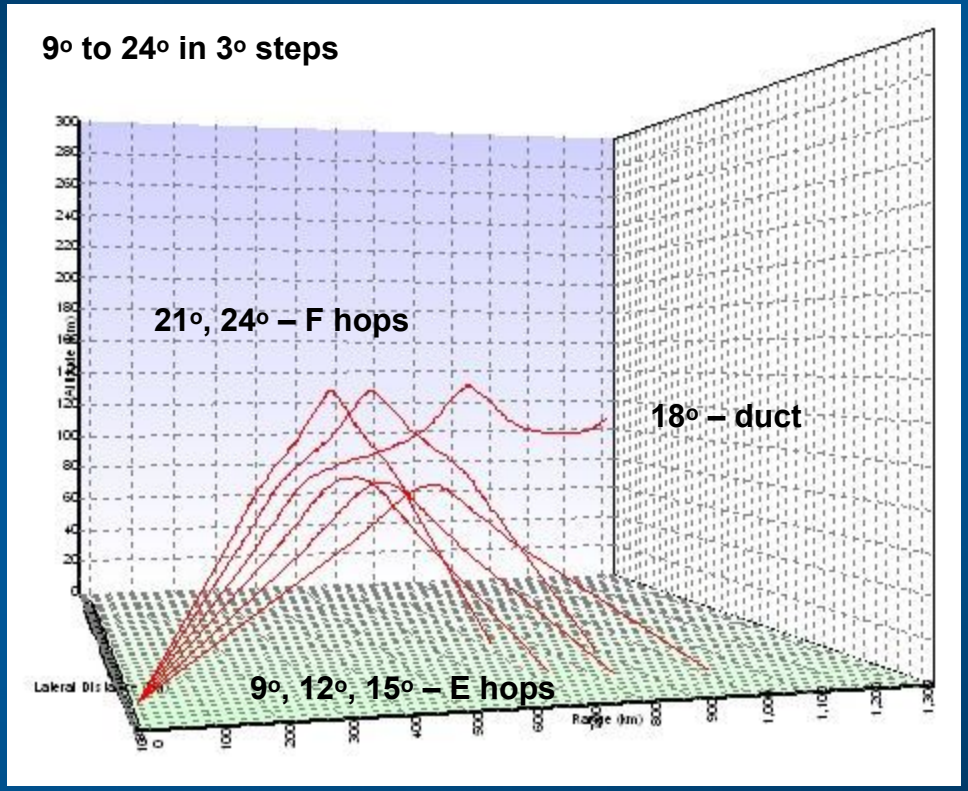


Figure 2 Electron Density Along the ST to W9 Path



- Duct allows extreme long distance QSOs due to less transits through the absorbing region and no ground reflection losses
- We need to invoke ducting because the multi-hop limit appears to be around 10,000 km based on 1 kW, verticals and quiet rural noise environment

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Required Elevation Angles

- In transmit you need to cover a wide range of angles – something like 10 to 25 degrees
  - Vertical or vertical array should be satisfactory
  - Importance of low angle E hops needs to be investigated
- In receive you need to cover a much wider range of elevation angles
  - Signals can come out of a duct at high angles
  - Only way to cover a wide range of elevation angles is to have many antennas in receive
  - Someone once said “you can’t have enough antennas on 16m”
- Polarization needs to be investigated, too

References

- ON4UN's Low-Band DXing
  - ON4UN, Fifth Edition, 2010, ARRL
- DXing on the Edge
  - K1ZM, 1997, ARRL
- Topband reflector
  - Moderated by N6TR
  - http://lists.contesting.com/mailman/listinfo/Topband
- W8JI web site
  - http://www.w8ji.com
- K9LA propagation web site
  - http://k9la.us, 160m link on the home page

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Summary

- Start simple
  - Try to use one of your existing antennas with a tuner
    - Good enough for local and many domestic QSOs
    - Any antenna radiates - some just do it better than others
- Then figure a way to put up a dedicated 160m antenna
  - I believe the best compromise for simplicity and performance is an inverted-L with one elevated radial
- Move towards incremental improvements
- Use antenna modeling to get a rough idea of what to expect
  - Don't be afraid to experiment – modeling may not necessarily equate to the real-world
- And always remember we'd like to keep 160m as "The Gentleman's Band"

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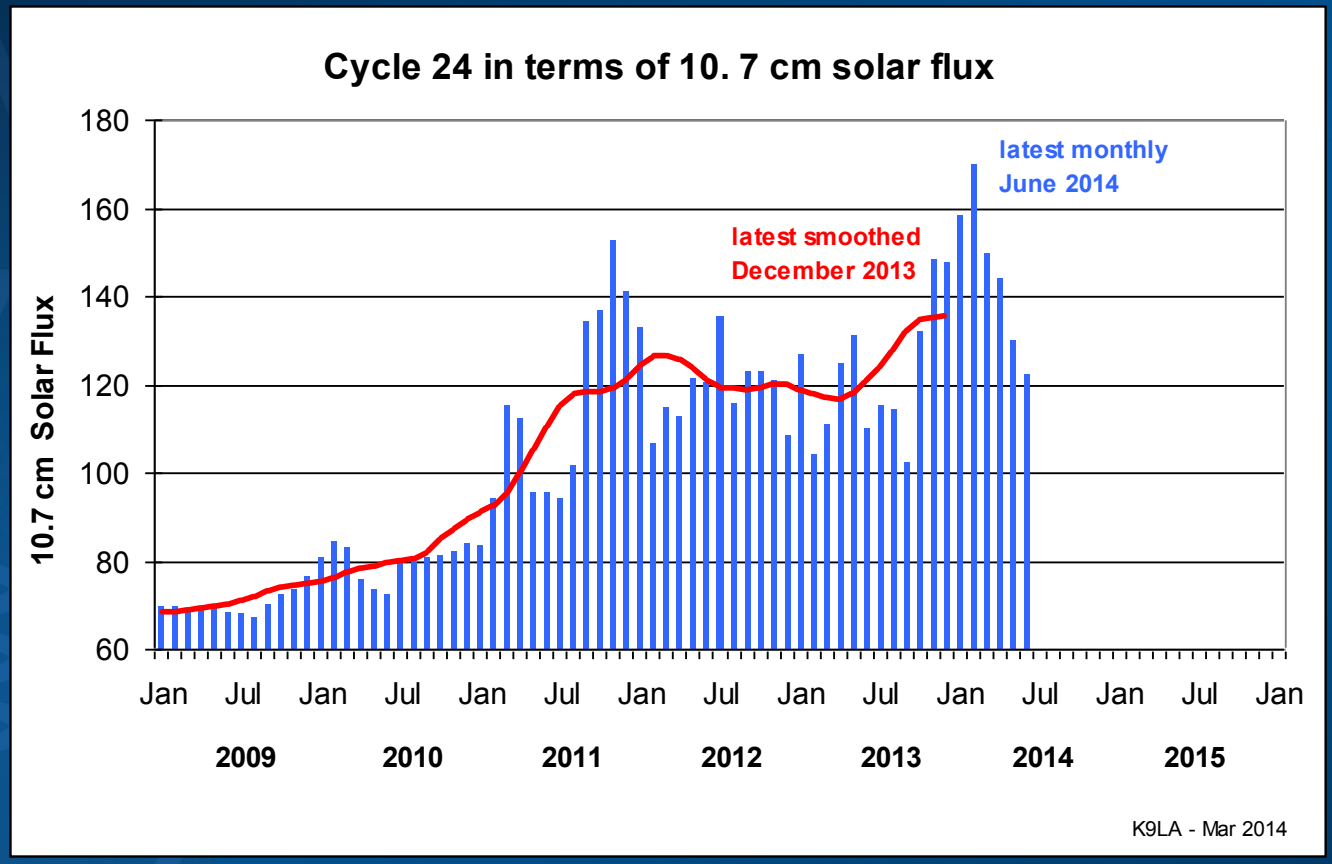
Cycle 24 Update



- First peak in early 2012
- Second peak around early 2014
- Higher bands should still be good this fall / winter

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